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Incidence and Cost of Depression After Occupational Injury

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Abstract

Objectives—We examined if injured workers were more likely than noninjured workers to be treated for depression after an occupational injury and estimated the cost paid by group medical insurance.

Method—Nearly 367,900 injured and noninjured workers were drawn from the 2005 Thomson Reuters MarketScan data. Descriptive, logistic, and two-part model regression analyses were used.

Results—The odds of injured workers being treated for depression within the study period were 45% higher than those of noninjured workers (95% confidence interval, 1.17–1.78). The unconditional average cost of outpatient depression treatment was 63% higher for injured workers than for noninjured workers.

Conclusions—Injured workers were more likely than noninjured workers to suffer from depression during the study period. Consequently, additional costs are incurred for treating injured workers' depression; these costs were not covered by the workers' compensation system.

Occupational injury and illness are significant sources of injury morbidity in the United States, with an estimated $67 billion in direct costs of medical care for these injuries and illnesses alone (2007 estimate).[1] Typically excluded from calculations of the costs of occupational injuries (and illnesses) are costs that are indirect or more difficult to quantify, such as the effects on a worker's activities or family life.[2] As noted by Nimgade et al,[3] most researchers in this area usually consider individual diseases or injuries, with little attention given to comorbidities. Mental health has long been tied to injury outcomes; however, mental health outcomes secondary to occupational injury are usually not included in the estimated costs associated with occupational injuries. These costs are usually borne by private medical insurance or by the workers themselves, as workers' compensation (WC) frequently does not cover such treatment. This underestimates the true costs of occupational injuries or illnesses. Most state WC systems do not recognize depression as a work-related and therefore compensable condition,[4] although depression has been linked to a preceding occupational injury[5,6] and has been found to be a factor influencing workers' success in

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returning to work.[7] Some studies have also attempted to determine whether workers with work-related injuries have a higher risk of developing depression and anxiety.[2,8,9] Nevertheless, there is little empirical work that directly examines the incidence and cost of depression after occupational injury.

The present study attempted to add to research in this area by examining whether injured workers were more likely than noninjured workers to be treated for depression after occupational injury. It also calculated the direct outpatient cost of medical treatment for depression after occupational injury during the study period. We hypothesized that, based on previous studies that have linked occupational injury and subsequent depression, injured workers would be significantly more likely to have been treated for depression and would incur more costs for treatment of depression than their uninjured counterparts during the study period.

METHODS

Data and Measurement of Variables

We used the 2005 Thomson Reuters' MarketScan Health and Productivity Management and Commercial Claims and Encounter data sets. The MarketScan databases cover 48 states and have been used extensively by researchers in different fields. Since the first article was published in *The New England Journal of Medicine* in 1990,[10] more than 200 peer-reviewed articles have been published using the MarketScan databases.[11] Data were provided by 16 large employers in the United States for a combined total of over 440,000 employees. The Health and Productivity Management data sets contain information about overall enrollment, absenteeism, short-term disability, and WC. The WC file has information about dates of injury, body part injured, cause of injury, number of workdays absent, indemnity, and medical payments. We used this data set to measure the incidence of injury. The enrollment file has information about age, gender, insurance type, days of enrollment, occupation type (hourly/salary), union status, industry, region, and other variables for all workers in the database. The Commercial Claims and Encounter data set has detailed information about the types and amount of health services used (drug, outpatient, inpatient). For this study, we used the outpatient file. Available information in this file includes date of service, International Classification of Diseases—Ninth Revision (ICD-9) codes, and total payments. Details about the MarketScan data can be found elsewhere.[11–15] Linking these data sets provides the information necessary to follow the before- and after-injury health status of injured workers, as well as the health status of all workers in the database. We used the anonymous and unique variable (*enrolid*) to link the different data files. Workers who were in the enrollment file for all 12 months of 2005 were eligible for this analysis. The overall sample selection procedure is presented in Fig. 1.

We compared the incidence and cost of depression for injured and noninjured workers within a window of 3 months after injury. This 3-month study period is expected to be long enough to capture the effect of injury and short enough not to capture the effect of other shocks, such as change in the health status of family members, death of a family member, and change in marital status of a worker. The 3-month postinjury time window is consistent

with that used by Levin et al[16] in their attempt to examine the impact of brain injury on depression and posttraumatic stress disorder.

Because dates of injury are not available for the noninjured workers, they were randomly assigned an index date or a "pseudoinjury date" that corresponded to the date of injury of the pool of injured workers. This means that every worker in our sample will have an injury date: a true occupational injury date for injured workers and a pseudoinjury date for noninjured workers. Therefore, the 3-month study period refers to 3 months after the actual date of injury for injured workers and 3 months after the pseudodate of injury for noninjured workers. We examined the sensitivity of our results to this procedure by changing the random seed number and found the results to be stable. So that we could follow all workers for 3 months before and after the injury date, injury cases (both actual and pseudo) occurring between January 1 and March 31 and between October 1 and December 31 (2005) were excluded (see Fig. 1).

Incidence of depression was measured by the primary outpatient diagnosis code (ICD-9 codes). Workers who were primarily diagnosed with any of the following ICD-9 codes within the study period were considered to suffer from postinjury depression: 296 (episodic mood disorders, except 296.1 manic disorder, recurrent episode and 296.4 bipolar disorder, most recent episode), 300.4 (dysthymic disorder), 301.1 (affective personality disorder), 309.0 (adjustment disorder with depressed mood), 309.1 (prolonged depressive reaction), and 309.28 (adjustment disorder with mixed anxiety and depressed mood). To control for the impact (including reverse causation) of preexisting depression, workers who were treated for depression within 3 months before the date of injury were not included in the study. There is no clear guidance to determine the cutoff period for preexisting depression. We used the 3-month cutoff period based on the study of Asfaw et al.[17]

Statistical Analyses

Descriptive and regression analyses were used to examine the association between occupational injury and the incidence of postinjury depression, and to compute the associated costs. A logistic regression model was used to estimate the association of occupational injury with postinjury depression, as measured by recorded outpatient visits for depression. The dependent variable was incidence of depression within the study period; the independent variable was occupational injury. Covariates included in multivariate models were all demographic and personal variables available in the MarketScan database: sex, age, age squared, sex, marital status, family size, class of worker (hourly vs salaried), health plan type, union status, industry, and region.

We used the logistic model instead of a Poisson regression for two reasons. First, very few (0.56%) workers had more than one outpatient visit. Second, as explained later, we needed the logistic regression results to estimate unconditional costs. Because of large numbers of zeros, we could not use ordinary least square methods to estimate the postinjury costs of depression (in our sample, only 1.05% of workers had outpatient depression visits within the study period). Two-part models are used to analyze cost data that include many zeros. As the name implies, the data are modeled in stages. In the first stage, the probability of a worker

having an outpatient depression visit within the study period is estimated. This can be modeled using either probit or logistic models. For the logit model:

$$P(d_i \leq 0) = \Phi\left(z'\beta\right)$$
$$[\text{Part 1:probability of outpatient depression visit}]$$

where *d* is an indicator variable that takes 1 if a worker *i* has an outpatient depression visit within the study period and zero otherwise, Φis the logistic cumulative distribution function, z is a vector of explanatory variables, and β is a vector of coefficients to be estimated.

In the second part, a log linear regression model (equation 2) is estimated to compute the outpatient cost of treatment for those workers who had an outpatient depression visit. This gives the predicted conditional outpatient depression costs.

$$E(y_i) = f\left(x'\gamma\right)$$
$$[\text{Part 2:predicted cost conditional on outpatient depression visit}]$$

where *y* is the log of outpatient depression cost, *x* is a vector of explanatory variables, which can be the same or different than *z* of equation [1], and γ is a vector of coefficients to be estimated. Then, the unconditional predicted costs can be computed as a product of the first and the second parts:

$$E(y_i/x) = prob(d_i \geq 0/z) \times E(y_i/\mathbf{X}, y_i \geq 0) \times D$$

where $\hat{D}$ is a smearing factor.

Equation [3] states that the unconditional outpatient depression cost can be computed as the product of the probability that a worker will have an outpatient visit for depression conditional on *z* and the expected outpatient depression cost conditional on *x*. To make useful conclusions about the estimated costs, transformed (log) costs should be retransformed to their original values. We used Duan's[18] smearing estimator to transform the unconditional log cost estimates to their original values. The smearing factor was computed as:

$$\hat{D} = \frac{1}{N}\sum_{i=1}^{N}\exp(\mu_i)$$

where μ_i is the residual from equation [2].

RESULTS

Incidence of Outpatient Depression

Descriptive Results—Descriptive statistics for the study population are presented in Table 1. Overall, 367,881 workers with complete information were eligible for this study. Of

these workers, 6513 (1.77%) were injured and filed for WC benefits in 2005. Nearly 3870 (1.05%) workers had an outpatient visit for depression within the study period. Figure 2 shows the percentage of workers treated for outpatient depression within the study period by injury status and the percentage difference (second axis) between the two groups of workers.

Although only 1.04% of noninjured workers had an outpatient depression visit, 1.49% of injured workers had an outpatient depression visit within the study period. This implies that the likelihood of injured workers suffering from depression within the study period was 43% higher than that of noninjured workers (two-sample test of proportion: $z = 3.50$; $P < 0.001$).

We examined the incidence of outpatient depression by gender. Generally, the literature shows that women are more likely to be depressed than men.[19,20] The results of our study are consistent with the literature in this area. Within the study period, 1.5% of women were treated for depression compared with 0.7% of men ($z = 22.933$; $P < 0.001$). As shown in Fig. 3, 1.9% of injured women were treated for depression within the study period compared with 1.1% of their male counterparts ($z = 2.444$; $P = 0.007$). Nevertheless, the *relative* effect of injury on depression was higher for male than for female workers. As Fig. 3 illustrates, 0.7% of noninjured male workers were treated for depression compared with 1.1% of their injured counterparts. Therefore, after injury, 53% more men were treated for depression versus 21% more women (second vertical axis of Fig. 3).

We also observed significant variation in the incidence of depression by age (not shown). Overall, the incidence of depression had a concave shape against age, indicating that depression problems increased up to age 31 to 40 years and declined after that for all workers. Nevertheless, at most age categories the incidence of outpatient depression was higher for injured workers than for noninjured workers.

MULTIVARIABLE RESULTS

We estimated a logistic regression model to examine the association between the incidence of occupational injury and the likelihood of depression within the study period after controlling for covariates, and the results are presented in Table 2.

The log likelihood and the logistic regression chi-squared test results reveal that the regressors were jointly statistically significant in explaining the incidence of outpatient depression visit within the study period at less than the 1% level. When the fitted and the actual values were compared, the model correctly specified 98.95% of the actual values. Most of the control variables took the expected sign and were statistically significant. The likelihood of female workers being treated for outpatient depression was more than 50% higher than that of male workers. Consistent with the descriptive analysis, age increased the incidence of outpatient depression but at a decreasing rate. Large family size increased the likelihood of treatment for depression. Nevertheless, married workers were less likely to be treated for depression than nonmarried workers. Workers in the finance and transportation industries were more likely to be treated for depression than workers in the reference manufacturing durable industry.

The coefficient of the injury variable took the expected positive sign and was statistically significant at less than the 1% level, indicating that occupational injury was associated with depression. After controlling for covariates, the odds of injured workers being treated for outpatient depression within 3 months after injury were 44% (95% confidence interval [CI], 1.17 – 1.78) higher than those of noninjured workers.

We plotted the predicted probability of outpatient depression for different groups of workers (Fig. 4). While the average probability of a worker being treated for outpatient depression within the study period was 0.97%, it was 1.38% for an average injured worker. At the same time, the probability of a 40-year-old single injured woman being treated for outpatient depression within the study period was 2.94% [95% CI, 2.27–3.61].

COST OF OUTPATIENT DEPRESSION

We examined the outpatient depression cost difference between injured and noninjured workers, conditional and unconditional, on depression. First, we estimated the conditional outpatient cost for injured and noninjured workers given an outpatient depression visit during the study period. A total of 3867 workers had an outpatient depression visit within the study period. We used equation [2] to compute the conditional outpatient depression costs after controlling for the effect of covariates.

The second column of Table 3 shows that the conditional (given visit) mean outpatient cost of depression within the study period was $295 [95% CI, $293–$296] for injured and $250 [95% CI, $248–$251] for noninjured workers, after controlling for covariates. There was a 17% outpatient depression cost difference between injured and noninjured workers ($t \leq 0.001$).

The conditional analysis, however, could not give us a cost difference figure that could be used for all workers, because costs were computed on the basis of information only from workers who had an outpatient visit for depression. In other words, the conditional cost difference figures could suffer from sample selection bias and the results might not be representative of all workers in the sample. Therefore, we used equation [3] to estimate the unconditional out-patient depression cost difference between injured and noninjured workers. The unconditional analysis, as explained in the Method section earlier, allows us to take into account two factors: the probability of being treated for outpatient depression (equation 1) and the level of the costs that were incurred for the treatment (equation 2) within the study period. In other words, equation [3] takes into account factors that affect the probability of a worker's having an outpatient visit for depression and the conditional costs. This procedure helped us to compute the unconditional outpatient depression costs for an average worker. The results of the two-part model are presented in the last column of Table 3.

The unconditional results showed that an injured worker in our sample would incurred an average of $5.03 [95% CI, $4.95–$5.10] outpatient depression cost within the study period. The average out-patient depression cost for noninjured workers within the same period was $3.08 [95% CI, $3.03–$3.12]. This means that the unconditional average outpatient depression cost for an injured worker was 63% higher than the average outpatient depression

cost for a non-injured worker after adjusting for covariates ($t = 136$; $P < 0.001$). The unconditional percentage cost difference between injured and noninjured workers (63%) was higher than that of the conditional percentage cost difference (17%) because the former takes into account the probability of workers' having any outpatient visit for depression.

DISCUSSION AND CONCLUSIONS

Occupational injury is a significant source of injury morbidity in the United States. It influences workers' psychological and physical well-being, which includes increasing their risk of suffering from depression-related illnesses. In this study, we examined whether injured workers were more likely to be treated for outpatient depression than their uninjured coworkers during the study period (3 months after occupational injury). Our results clearly showed that injured workers were more likely than noninjured workers to suffer from depression during the study period.

This study adds to the literature suggesting that occupational injury may be followed by depressive episodes. Although more analysis should be done in this area to confirm this finding, including analyses conducted over longer follow-up periods; the occupational health community, employers, and others may reasonably anticipate that injured workers may need mental health services. Although women, whether injured or uninjured, were more likely to be treated for outpatient depression, the relative effect of occupational injury was larger on men. In other words, although fewer men were treated for postinjury depression, the before- and after-injury increase was larger for men. One hypothesis explaining this result is that men are more deeply affected by occupational injuries and therefore have a higher than “expected” rate of depression treatment. When we predicted the probability of depression after injury for different worker groups, marital status and family size also emerged as factors associated with likelihood of after-injury depression.

The results of this study may also have significant cost implications for the nation as a whole. According to the Bureau of Labor Statistics, in 2005, 4.2 million cases of injury were reported in the country. In terms of outpatient medical costs alone, after-injury depression costs workers, group health insurance plans, and/or taxpayers at least an extra $8.2 million (4.2 million × $1.95) within a 3-month study period in 2005 dollars. Such costs of treating depression as a sequel to injury are typically not included in estimates of the economic burden of occupational injury. This analysis is limited to the cost of outpatient visits for depression. Diagnoses of depression may involve additional medical expenses, such as the cost of prescription drug, that are not reflected here (we could not uniquely link the prescription drug file to the WC and outpatient service files). Therefore, the costs for treating depression during the 3-month period after injury may be underestimated.

Although several previous studies have shown links between occupational injury and depression, this study is the first to use deterministically linked WC and medical insurance data to examine the incidence of depression after occupational injury. Although the use of administrative data for research has some drawbacks, the use of medical and WC claims data avoids the limitations that can be associated with surveys, including issues of recall and self-report. There are also several limitations of this study. Occupational injury is defined as

an injury recorded in the WC file. Research has established that there are barriers to reporting to WC systems and that many eligible workers do not report their injuries.[21–24] Underreporting of occupational injuries could affect or bias these results. For example, if injured workers are truly more likely to develop depression after injury and workers underreport their injuries (but do seek treatment for depression), then the relative risk of depression would be biased toward the null. Nevertheless, it is difficult to predict the direction of any potential bias, as the relationship between reporting injuries and seeking treatment for depression is unknown.

Because of the data structure and the potential endogeneity of the injury variable, we are unable to evaluate causality between occupational injury and depression. In addition, several studies have indicated that mental health disorders and other potentially associated health problems, such as being overweight or obese, may be risk factors for unintentional injuries, including occupational ones.[5,25–27] The likely bidirectional nature of the relationship between depression and occupational injury may invite the suggestion of reverse causation. We have made efforts to avoid observing reverse causation in this study by restricting the data set to workers without outpatient visits for depression during the previous 3 months. Bias away from the null is still possible if injured workers were more or less likely to have untreated depression that they sought treatment for only after their occupational injury. For example, if untreated depression (or treated more than 3 months in the past) contributed to occupational injury and those workers were then likely to seek treatment for their depression, then the estimated incidence of new depression among injured workers would be an overestimate.

Our cost estimates could also underestimate the actual burden of after-injury depression, because the incidence and cost of depression were computed on the basis of the principal diagnosis codes (secondary depression diagnosis was not considered). The deletion of workers who had a depression claim within 3 months before injury also could underestimate our results, because injuries could also exacerbate or prolong depression for this deleted group. In addition, our study design did not allow us to consider injured workers who might develop minor psychiatric troubles and sought self-medication with over-the-counter medicines. All these factors could underestimate our odds ratio and cost estimates.

Finally, the impact of occupational injury on the overall health status of injured workers is unlikely to be limited to depression. Further study could explore the total number of claims and costs for all conditions after work injury.

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Learning Objectives

- Discuss the new findings on the incidence of depression after occupational injury.
- Outline sex-related differences in the incidence and relative risk of outpatient treatment for depression after occupational injury.
- Summarize the estimated costs of depression after occupational injury and their contribution to the total costs associated with such injuries.

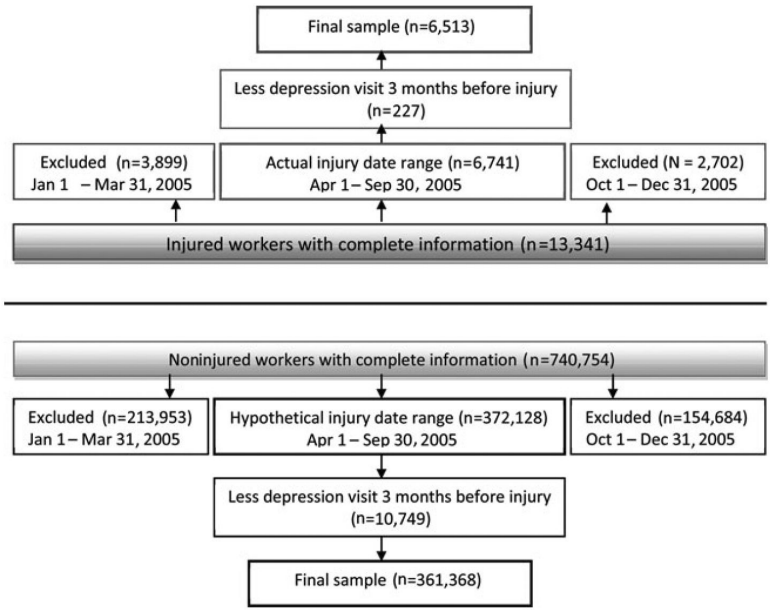

FIGURE 1.
Sample selection procedure.

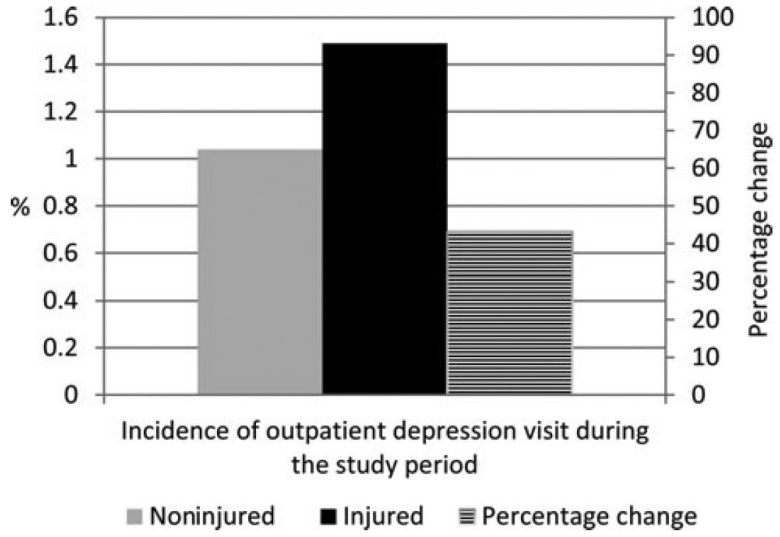

FIGURE 2.
Incidence of outpatient depression visit within 3 months.

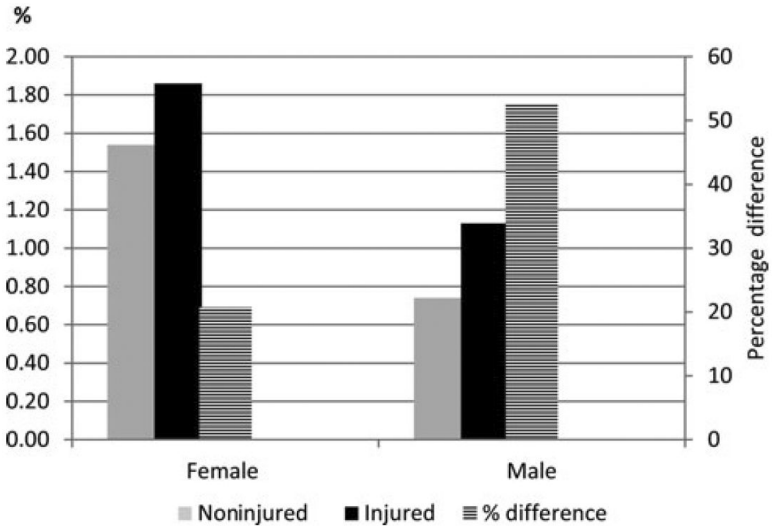

FIGURE 3.
Incidence of outpatient depression by sex.

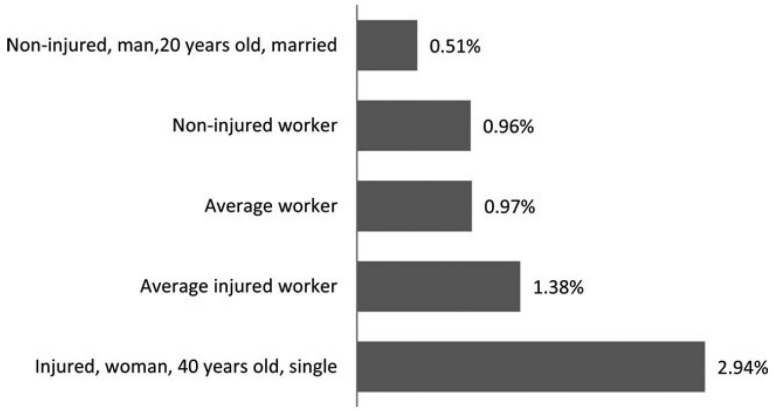

FIGURE 4.
Probability of being treated for outpatient depression within 3 months after injury.

TABLE 1

Descriptive Statistics

Variable	Mean Value	
	Noninjured (*n* = 361,368)	Injured (*n* = 6513)
Depression incidence (1, if a worker was treated for depression [outpatient visit] within the study period and 0 otherwise) (%)	1.04	1.49
Depression outpatient costs within the study period (given visit)	$246	$252
Depression outpatient costs within the study period (for all)	$2.57	$3.75
Age (yr)	43.0	43.9
Men	62.2	50.5
Women	37.8	49.5
Married (%)	56.3	49.7
Family size (no.)	2.5	2.3
Hourly worker (%)	55.30	82.44
Union member (%)	59.7	48.9
Industry (row sum %)		
Manufacture durable	98.52	1.48
Manufacture nondurable	98.33	1.67
Transportation	99.46	0.54
Finance	99.91	0.09
Service	94.21	5.79
Region (row sum %)		
Northeast	99.37	0.63
North Central	98.05	1.95
South	97.58	2.42
West	98.61	1.39
Unknown	99.92	0.08

TABLE 2

Determinants of Incidence of Outpatient Visit for Depression: Logistic Regression Results

	Odds Ratio	SE	95% Confidence Interval
Sex (1, male and 0 otherwise)	0.477**	0.017	0.445–0.511
Age (yr)	1.086**	0.015	1.057–1.115
Age^2	0.999**	0.000	0.999–0.999
Family size (no.)	1.049**	0.017	1.016–1.082
Marital status (1 married and 0 otherwise)	0.885**	0.040	0.810–0.968
Occupation (1, hourly and 0 otherwise)	0.918*	0.035	0.852–0.990
Union	1.042	0.041	0.964–1.126
Injured	1.445**	0.153	1.174–1.778
Health plan type (HMO, reference)			
POS	0.954	0.056	0.850–1.071
PPO	1.070	0.062	0.955–1.200
CDHP, Comp, EPO	1.115	0.108	0.922–1.349
Industry (Manufacturing durable, reference)			
Manufacturing nondurable	1.007	0.056	0.904–1.122
Transportation	1.199**	0.066	1.076–1.336
Finance	1.241**	0.079	1.094–1.406
Service	0.990	0.056	0.886–1.107
Region (Northeast, reference)			
North Central	1.148**	0.055	1.045–1.262
South	0.961	0.043	0.880–1.050
West	1.154*	0.074	1.018–1.308
Unknown	1.274	0.248	0.871–1.865
No. observations		367881	
Log likelihood		−21129	
LR chi-square (19)		665.60	
Probability > chi-square		0.0000	
Pseudo R^2		0.0155	

* and ** indicate significance at the 1% and 5% levels.

CDHP, consumer direct health plan; EPO, exclusive provider option; HMO, health maintenance organization; LR, loglikelihood ratio; POS, point of service plans; PPO, preferred provider organization.

TABLE 3

Conditional and Unconditional Outpatient Depression Cost Within 3 Months After Injury

	Conditional		Unconditional	
Variable	**Mean**	**95% CI**	**Mean**	**[95% CI]**
Injured	$295	$293–$296	$5.03	$4.95–$5.10
Noninjured	$250	$248–$251	$3.08	$3.03–$3.12
Difference	$45	$45–$45	$1.95	$1.92–$1.98
Mean percentage difference	17.93		63.43	
No. observations (logistic regression)			367,881	
No. observations (log linear)	3867		3867	
Mean difference, *t* =	324.29		136.36	
Ha: mean (difference) > 0: *P* (T > t)	0.000		0.000	
Ha: mean (difference) ! = 0: *P* (T > t)	0.000		0.000	

CI, confidence interval; Ha, hypothesis.